# Science behind Sustainable Seafood: Age Matters!

## Brief Overview

There are over 25,000 species of fishes throughout the world. Species of fish are differentiated by physical characteristics such as number of fins, shape of body, an online game called Fish IQ game will provide students with a background on what is and isn't a fish.  It will also describe how fishes can live over different habitats, from rocky intertidal areas to the bottom of the ocean and pelagically in the open ocean. Not only do fish look different and live in different locations, but they may grow differently too. After learning a little bit about fish biology, the students will then be ready for a more in depth activity to discover why age information is important in understanding the health of a fish population.

The Age Matters! activity will allow students to use real data from the NOAA Fisheries Alaska Fisheries Science Center Age and Growth program to develop age/length graphs for the population as a whole and age/length graphs for the part of the population that is part of a commercial fishery. Students will also learn the importance of the age at reproductive maturity for determining if a fish population is being sustainably harvested.

### Age matters!

Fishery scientists have learned that knowing a fish population's age structure means knowing how old the fish can get, how many individuals in the population are at each age and how old a fish is when it first spawns. Scientists have learned that some fish grow fast and live less than 10 years, and other fish grow slow and live to be over 100 years old. This means that some species may become mature enough to spawn at a young age, such as less than 6 years old.  Other species may not spawn until they are over 20 years old.

Why is this important to sustainable seafood? Age is important to know because a sustainably harvested population means not harvesting fish when they are too young or too old. Both would decrease the size of future populations.

### How do scientists age fish?

They use otoliths! Similar to trees, otoliths have rings that can be counted. What are otoliths? Otoliths are hard calcified structures located in the ear of a fish. Their function is to help the fish detect sounds, and provide a sense of balance as the fish swims. Otoliths are good for aging because a new layer is added to it almost every year throughout the life of a fish. Unlike tree rings, otolith rings are generally more faint and irregular to see, making them harder to count.

The activity may take up to two 50 minute periods, if a review of basic fish biology is needed. First 50 minute period will be to review basic fish biology, second 50 minute period will go into why knowing age distribution of a harvested fish population is important and include an age and growth data manipulation activity.

**Big Ideas:** Populations have age structure.
**Essential Question:** Why is age information important to understand the health of a fish population?
**Objectives:** The learner will be able to discuss the process of how fish are aged, understand importance of age composition of a population, age at reproductive maturity.

## Key Subjects/Standards

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|---|---|
| National | **Science**: NS.9-12.1 Science as Inquiry. NS 9-12.3 Life Science: Interdependence of organisms, Behavior of organisms. NS 9-12.6 Personal and Social Perspective: Population growth, Natural resources, environmental quality. **Math**: NM-NUM. 9-12.3 Number and Operations: compute fluently and make reasonable estimates. NM-PROB.CONN.PK – 12.3 Connections: recognize and apply mathematics in contexts outside of mathematics. |
| Ocean Literacy | 5. The ocean is filled with diversity.<br><br>6. The ocean and humans are inextricably interconnected (b, c, e, g). |

## Teacher Preparation

1. Read the entire activity and review all background material and resources.
2. Determine the amount of time you would like to dedicate to this activity. If classroom time is readily available, a minimum of two 50-minute classroom periods is advised. If classroom time is limited, students may complete some of their tasks as homework.
3. Determine the best assessment strategy for your class based on suggestions made by authors.

## Materials List

- Student Data set (survey and fishery data)
- Teacher data set with what graphs should look like
- Otolith samples if available

## Background

Fish have been a source of protein for humans and other animals for millennium, but with the rise in the global human population, protein sources will become more important to manage. Fish come in all shapes and sizes, some species have been more popular sources of food than others, such as Cod or Halibut. Although some humans fish for sport, we will not consider that in our discussion, only to say that recreational fishermen may or may not keep their catch for food and when they do catch them for food, then management measures should be considered.

### Why do humans eat fish?

Fish are a valuable source of protein.
Long ago, man only caught as much fish as he needed to feed himself and his tribe. As populations grew, not everyone could go fishing. Fishing became an occupation and not just a necessary task to find food. Fish was still a food, but it became a commodity, something that could be bought and sold. As civilizations evolved, so did fishing techniques and the ability to catch more fish grew more efficient. Fishing grew from small fleets that fished near to shore, to big fleets that fished further and further away from the communities the fishermen were from. It is believed that fishermen from Europe searching for Cod were the first to discover America, but they never went ashore as they were only interested in fishing.

In the 1900s, fishing was still an unregulated industry, fish stocks continued to supply the voracious appetite of fishermen worldwide. It was the advent of highly technical gear around the time of WWII that fishing became more efficient and boats big enough to fish thousands of miles away from their home country were built. Fish stocks started become depleted and governments around the world realized that regulation was necessary to ensure that the ocean could continue to provide this healthy source of protein and jobs.

Numbers of fish wasn't the only piece of information that fishery scientists were looking for. They needed to know the age structure of the population and what part of the population was being targeted in the fishery. As more information about the age and growth of fishes became known, it became apparent that not all fish were created equally. Some fish grew fast and lived only a few years, some fish grew slow and lived to be over 100 years old.  Management measures for the short-lived/fast growing fish had to be different than those for long-lived/slow growing fish.

Size limits had been used in the past as a way to manage certain fish populations, if the fish is too small, the regulations are to throw it back with minimal injury, in some cases if the fish is too big, such as with halibut, then the regulations are the same. For both the rationale is rooted in the fishes reproductive cycle: fishery managers do not want to fish out the young fish before they spawn and they do not want to fish out the old females who produce more eggs than the really young females.
The other important piece of knowledge we get from knowing how old fish get is how old they are when they recruit to the fishery. In other words, how old are they when the gear used by the fishery can catch them.

### What is an otolith?

Otoliths are hard, calcareous bodies, located in the cranial bones near the brain of teleost fishes. Otoliths, sometimes referred to as ear bones, are of unique value for age determination of teleost fishes because across taxa they are the only hard structures that continue growing even after somatic growth has ceased. In cartilaginous fishes such as sharks and skates, otoliths are not well-calcified, so researchers must rely on other hard structures such as vertebrae or spines for age estimation. Although annual marks in otoliths and vertebrae are similar to tree rings, their appearance is generally much fainter and more irregular. Another major problem in counting annual marks is that the timing of the deposition of new growth zones varies considerably by species, age, and exogenous factors such as geographic location and climate. These issues may increase the difficulty of interpreting annual marks in aging structures, thus requiring the specialized expertise of biologists trained in age determination.

### Why age data are important?

Age data can provide considerable insight into fish population dynamics. Age determination is particularly important for marine fishes because they are often difficult to census at every life cycle stage. At the National Marine Fisheries Service's Alaska Fisheries Science Center (AFSC), fish age data, including catch-at-age data collected from commercial fisheries and population age compositions estimated from scientific bottom trawl surveys, are used to develop age-structured stock assessment models. These models evaluate the overall health of fish populations and guide fishery managers in setting sustainable catch limits. Age determination science relies on growth marks deposited on a daily or annual basis within the hard structures of marine organisms.

## Instructional Strategies/Procedures

### Exploration

Intro to fish biology

1. Review what a fish by using the Fish IQ quiz on the Alaska Fisheries Science Center education website.
    a. Have students work alone or do it as a class.

2. Watch video about the University of Washington's fish collection to see some weird looking fish you may not see at an aquarium: http://youtu.be/7-H8vs1iSBw

Intro to Age and Growth of Fish

1. Have the class watch video on How do scientists age a fish?

2. Have students either as a class or individually try their hand at ageing a fish by counting the layers of an otolith in this online demo.

### Engagement

Lab activity to determine age/length relationships in pollock

1. Give student pairs (lab partner) excel spreadsheet with data from sample pollock population. Alternatively, go through the following by showing the respective powerpoint slide that shows the finished graphs for each section.
2. Data are in excel spreadsheet – Graph
3. In excel spreadsheet titled "age data lesson 3" look for the worksheet with the abundance of pollock at age:
    1. plot abundance versus age - using XY scatter plot
    2. calculate the average abundance at age then plot

4. Look for worksheet with weight at age by year,
    1. Plot weight at age by year using a histogram
    2. Follow cohorts through time to see progression of strong/week cohorts.
    3. What years had strong cohorts?

5. Look at same data but from the fishery, data sheet is labeled catch at age
    1. At what age do pollock recruit to the fishery?
    2. What range of ages is caught in the fishery?
    3. Does the survey sample those ages? Are there any ages the survey does not sample?
        1. Why?
        2. What type of gear may be able to sample these ages better?
6. Look up the age at maturity for a pollock
    1. Hint: You can find it in the equation at the bottom of the abundance at age table in the excel file.
    2. Or you can look it up in the 2011 EBS Pollock stock assessment.
    3. See extension window for an extra credit idea.

### *Extensions & Connections*

- Calculate growth (estimate k) using von Bertalanffy growth equation - http://www.pisces-conservation.com/growthhelp/index.html?von_bertalanffy.htm
- More discussion about the von B growth equation from FAO - http://www.fao.org/docrep/W5449E/w5449e05.htm
- Calculate natural mortality (M). With information of total abundance of fish of a particular age within a population have the students determine what the natural mortality rate is for the population. They can calculate this by subtracting year a from year b and then dividing the result by year a and then times 100 to get the percent mortality, if there is more than one year between year a and year b, divide the answer by the number of years to get an average percent mortality. The published natural mortality rate for Pollock is .3. Do your data give you this answer?
- Visit a fish collection near you - In the Seattle area visit the Ichthyology collection a partnership between the Burke Museum and the University of Washington.

## Assessment

1. Reflection: Have students reflect on a question about fish biology:
    1. Why there are so many fish species in the ocean?
    2. Why do some fish get older than others, what are some pros/cons to growing slow/living long versus growing fast/living short?
    3. What part of the population would you want to fish if you are a fisherman to ensure that there are fish left to propagate future generations?
2. Age/Length data analysis: Students will have to provide lab write up with graphs of data, Title, purpose, methods, results, and conclusions.

**Vocabulary:** Age composition, population, otolith, life history, natural mortality

### Possible Misconceptions

All bottom trawling is bad.
All fisheries are overfished.
Fishers are bad and don't care about the environment.
Fish are short lived.

## Reflection on Roles

Have students break up into their groups – Industry, scientists, concerned citizens and council members. Have them reflect on what today's lesson may be relevant to their supporting statements they will be giving to the council members. Council members can reflect on what they would expect to see from each group.

## Project Evaluation

At the end of the project the teacher should fill out the SBSS Evaluation.

## Resources for Teachers

Age/Length data visualization from Alaska Fisheries Science Center
http://www.afsc.noaa.gov/REFM/Age/dynamic_maps/agemap.html

Fish IQ game online
http://www.afsc.noaa.gov/education/Activities/fish_iq_quiz.htm

All graphs for activity available on powerpoint as well as teacher key.